Operation specific engine load pattern and emission data from vehicles used in typical agricultural operations

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Purpose

The purpose of the work was to present operation specific:

- engine load data
- fuel consumption data
- emission data

from vehicles used in typical agricultural operations.

Why measure engine emission data for use in LCA of agriculture?

Ex. LCA Wheat prod.	Energy use MJ/ha	GWP CO2-eqv g/ha	AP H^{+-}eqv Mol/ha
Total	10 800	1520000	158
Engine emissions	3 300	242 700	71
	30 %	16 %	45 %

… and why operation specific values?

	g/MJ$_{fuel}$		
	CO	NO_X	HC
LCA-it	0.300	1.300	0.200
Audsley-97	0.693	1.360	0.218
Harrowing	0.046	0.840	0.015
Stump pulling	0.083	0.687	0.026
Ploughing	0.091	0.901	0.024
Sowing	0.114	0.864	0.028
Round baler	0.226	0.791	0.045
Front end loading	0.407	1.124	0.055
Transport	0.106	0.652	0.030

EMMA-project

- This study presents operational specific engine load and emission data for agric.

Part of a big project also studying:

- Effects of transient engine loads
- Simulation on varying engine control strategies
- Other machine types

For more details and publication list

www.jti.slu.se/emma

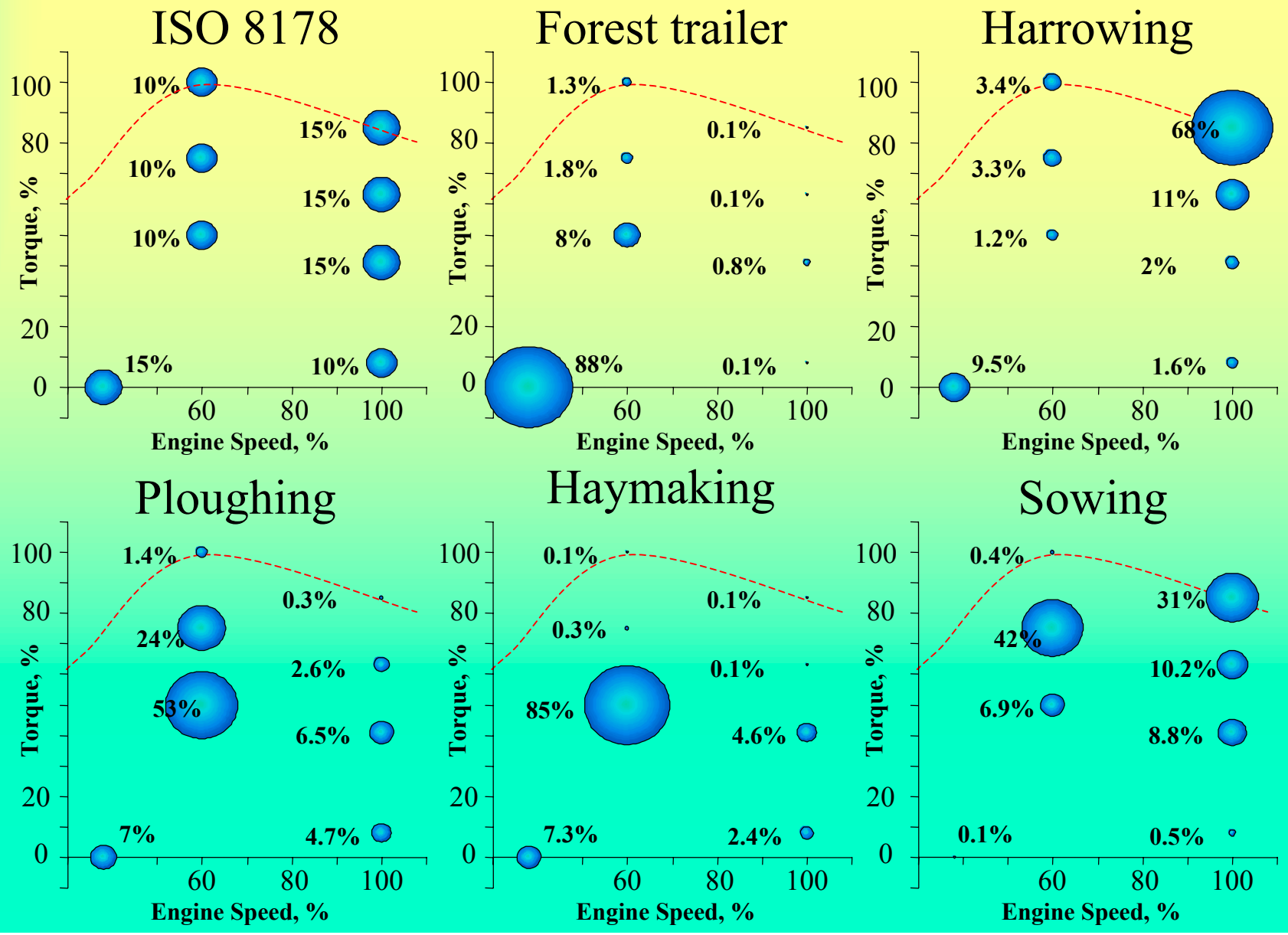
Studied vehicles

Methodology

1. Measurement of engine speed, fuel consumption and several other variables in real work operations (1Hz)
2. Calculation of loading torque time series from recorded data and test bench values
3. Test bench measurements of engine emissions at 20 combinations of engine speed and loading torque
4. Development of a matrix describing emissions for all possible combinations of engine speed and torque
5. Calculation of emissions for the studied operations by combining 2 and 4

Example: NO_X for Valmet ?

Results 1: ex load distribution



Results 2: ex of emissions

Operation	Power %	Work rate ha/h	Fuel kg/h	Emissions (g/h) CO	NO_x	HC	Vehicle
Bale wrappers	27		5.0	22.3	236	5.9	Valtra 6600
Baler	56		9.5	22.9	369	9.3	Valtra 6600
Fertiliser spreader	21	11.0	4.4	32.3	181	7.2	Valtra 6600
Forest trailer	2		3.0	36.1	148	6.2	Valtra 6600
Harrowing, heavy	90	4.9	14.8	99.8	716	10.3	Valtra 6650
Harrowing, normal	76	8.0	12.8	27.0	469	10.2	Valtra 6600
Mower conditioner, heavy	79	2.5	12.9	25.8	512	9.4	Valtra 6600
Mower conditioner, light	33	1.6	6.8	24.3	172	9.1	Valtra 6650
Ploughing	68	0.7	11.6	27.5	449	9.4	Valtra 6600
Ploughing	80	0.6	13.5	88.9	624	10.2	Valtra 6650
Ploughing	70	1.9	34.4	107.8	1202	11.7	Case IH
Precision chopper, heavy	99	0.8	17.3	30.8	618	10.6	Valtra 6600
Rolling	37	5.8	6.9	17.2	216	7.5	Valtra 6650
Semi-liquid manure spreader	53	6.9	10.3	29.5	310	11.4	Valtra 6650
Solid manure spreader	59	2.4	10.5	33.6	385	10.4	Valtra 6650
Sowing	48	6.6	24.3	79.0	679	11.2	Case IH
Sowing, high engine speed	52	2.3	9.5	29.0	311	10.7	Valtra 6600
Sowing, low engine speed	41	2	7.6	21.2	243	8.4	Valtra 6650
Stubb puller	92	1.3	15.9	30.0	564	10.7	Valtra 6600
Tedder	32	2.2	6.2	25.8	241	7.9	Valtra 6600
Transport of gravel	35		6.4	33.3	257	7.9	Valtra 6600
Transport of manure	79		13.3	87.5	596	10.8	Valtra 6650
Transport on country road	72		12.3	62.5	496	10.9	Valtra 6650
Urine manure filling	15		4.1	40.4	140	8.8	Valtra 6600
Urine manure filling	22		5.9	28.0	102	9.5	Valtra 6650
Urine manure spreader	37	4.4	7.0	25.0	267	8.6	Valtra 6600
Urine manure spreader	35	6.7	6.7	23.5	181	8.5	Valtra 6650

Results 3: more emissions

Operation	Emissions (g/MJ)			Vehicle
	CO	NO_x	HC	
Bale wrappers	0.103	1.092	0.027	Valtra 6600
Baler	0.056	0.899	0.023	Valtra 6600
Fertiliser spreader	0.170	0.952	0.038	Valtra 6600
Forest trailer	0.278	1.142	0.048	Valtra 6600
Harrowing, heavy	0.156	1.119	0.016	Valtra 6650
Harrowing, normal	0.049	0.848	0.018	Valtra 6600
Mower conditioner, heavy	0.046	0.918	0.017	Valtra 6600
Mower conditioner, light	0.083	0.585	0.031	Valtra 6650
Ploughing	0.055	0.896	0.019	Valtra 6600
Ploughing	0.152	1.070	0.017	Valtra 6650
Ploughing	0.073	0.809	0.008	Case IH
Precision chopper, heavy	0.041	0.827	0.014	Valtra 6600
Rolling	0.058	0.724	0.025	Valtra 6650
Semi-liquid manure spreader	0.066	0.696	0.026	Valtra 6650
Solid manure spreader	0.074	0.848	0.023	Valtra 6650
Sowing	0.075	0.647	0.011	Case IH
Sowing, high engine speed	0.071	0.757	0.026	Valtra 6600
Sowing, low engine speed	0.065	0.740	0.026	Valtra 6650
Stubb puller	0.044	0.821	0.016	Valtra 6600
Tedder	0.096	0.899	0.029	Valtra 6600
Transport of gravel	0.120	0.929	0.029	Valtra 6600
Transport of manure	0.152	1.037	0.019	Valtra 6650
Transport on country road	0.118	0.933	0.021	Valtra 6650
Urine manure filling	0.228	0.790	0.050	Valtra 6600
Urine manure filling	0.110	0.400	0.037	Valtra 6650
Urine manure spreader	0.083	0.883	0.028	Valtra 6600
Urine manure spreader	0.081	0.625	0.029	Valtra 6650

Estimation of emissions from vehicle not studied in this work

Example

Input data from inventory:

- Operation: ploughing
- Fuel cons.: 22.5 l/ha
- ISO 8178 emission data for engine used

Input from this study:

- Operation specific load pattern for ploughing

Output:

- Operation specific emission values in g/ha

ISO mode	ISO test g/h	ISO test g/h	Load distrib. ploughing
1	1520	43 240	61%
2	1010	33 280	8%
3	620	23 120	6%
4	350	7 770	9%
5	1550	41 900	6%
6	960	32 220	2%
7	550	21 780	5%
8	76	1 720	3%

1 220 g NO_X/h

35 420 g fuel/h

22.5 l/ha → 630 g NO_X/ha

Conclusions

Operation specific:

- engine load data
- fuel consumption data
- emission data

from vehicles used in typical agricultural operations are presented.